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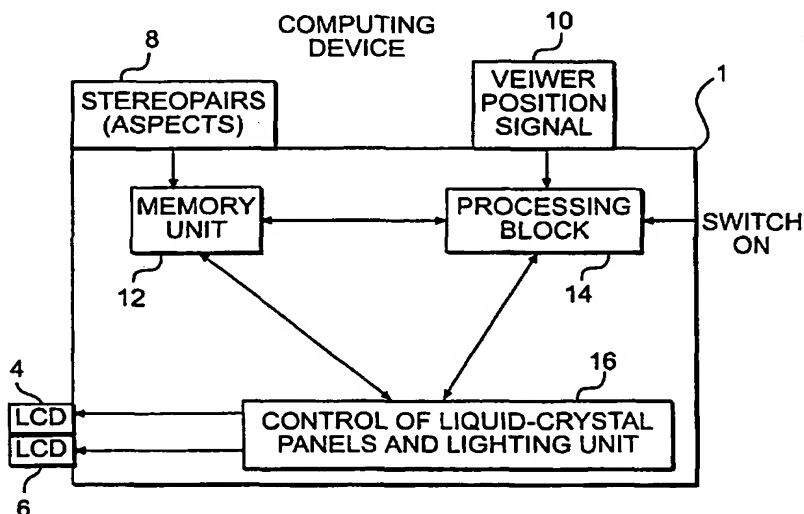
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ning of each regular issue of the PCT Gazette.

(54) Title: **VOLUMETRIC DISPLAY DEVICE**



(57) **Abstract:** A system and method of the display and viewing of multi-aspect imagery. Viewer position is determined as used as a basis for the staging and display of multi-aspect (stereo) imagery. Through use of three LCD panels, a distant panel having luminous radiation corresponding to portions of a multi-aspect image, and medium-distant, and near LCD panels which are transmissive and which are all regulated by a processor, those aspects of the image pair corresponding to the view of the left and right eye of the viewer can be seen. When the total light energy for a given cell of the LCD panels exceeds a certain threshold an error figure is calculated. When the error exceeds a certain error threshold, the luminous radiation of the distant panel is adjusted and/or a new image is staged.

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## VOLUMETRIC DISPLAY DEVICE

Field of the Invention

This invention relates generally to a stereoscopic display of images and related apparatus. More specifically, the present invention is a system and method for 3-D visualization based on parallel information processing of stereo imaging on multi aspect displays.

Background of the Invention

Stereoscopic display of images has become increasingly important in modern times. For example, training of professionals from pilots to physicians now frequently relies upon the visualization of stereographic images. Further, it is important that multiple aspects of an image be able to be viewed so that, for example, during simulations of examination of human or mechanical parts, a viewer can have a continuous stereoscopic view of those parts without having to change data or switch images.

Conventional stereoscopic display systems have been in use for many years. All of these rely upon segregating images for the right and left eyes. For example, an apparatus which sequentially displays different views to the left and right eye of a viewer has been used successfully in cartographic and other applications. In this instance, using stereo image alternation, a different view is sequentially presented to the left and right eye of the viewer. This is also accomplished by using cathode ray tubes or liquid crystal displays whereby a viewer wears special glasses such as polarizing glasses or liquid crystal shutter glasses in order to see a different image in the left and right eye.

Lenticular lenses have also been used to allow a viewer to see a left and right image separately when a viewer is at an optimum distance from the lenticular lens screen. For example Patent Number 5,838,494 to Araki was issued for an "Apparatus for Displaying Image Allowing Observer to Recognize Stereoscopic Image." This apparatus uses a lenticular screen displaying a

1 plurality of striped images each stripe corresponding to the parallax view of the  
2 left and right eye when the user is looking through the lenticular screen. This  
3 apparatus presents a limited number of views of a stereo image pair and is  
4 therefore limited in the number of views that can be displayed.

5       Patent Number 5,930,037 was issued to Imai for a "Stereoscopic Display  
6 Apparatus Which Prevents Inverse Stereoscopic Vision." This invention relates to  
7 the use of lenticular lenses to see stereoscopic image but also prevents the  
8 phenomenon known as inverse stereoscopic viewing when the right eye sees the  
9 image that is destined for the left eye and vice versa. While this does prevent a  
10 certain phenomena from occurring, this invention is limited in the number of  
11 stereoscopic image pairs that can be present to a particular user.

12       Patent Number 5,712,732 was issued to Street for an "Auto Stereoscopic  
13 Image Display Adjustable for Observer Location and Distance." This invention  
14 was created to account for the fact that, when a lenticular lens is used, a viewer  
15 must be at a particular distance from the lens in order for the lens to operate  
16 correctly. This invention comprises a distance measuring apparatus allowing a  
17 system to determine the position of the viewer's head in terms of distance and  
18 position (left-right) relative to the screen. In this fashion an appropriate stereo  
19 graphic image pair can be presented to the user at any particular location. Again  
20 this invention relies upon a lenticular screen to separate the parallax views for the  
21 left and right eye of the viewer. The head location apparatus dictates various  
22 other geometries associated with viewing the stereo graphic pairs of an image.  
23 However, this invention relates to adapting for the location of the viewer's head  
24 during such viewing and is limited in the number of aspects of images that can be  
25 created.

26       What would be desirable is a system that provides numerous aspects or  
27 "multi aspect" display such that the user can see many aspects of a particular  
28 object when desired. It would further be useful for such viewing to take place in a  
29 flexible way so that the viewer is not constrained in terms of the location of the  
30 viewer's head when seeing the stereo image.

1    Summary of the Invention

2           It is therefore an objective of the present invention to provide for multi  
3    aspect image viewing to created a stereo image.

4           It is a further objective of the present invention to be able to present an  
5    unlimited number of aspects of an image to a viewer so as not to lose any  
6    information while simultaneously having a full stereo image presented to the  
7    viewer.

8           It is yet another objective of the present invention to simplify the 3-D  
9    visualization of objects.

10          It is a further objective of the present invention to improve the perception of  
11   three dimensional information to a viewer.

12          It is a further objective of the present invention to remove sources of error  
13   from the viewing of stereo graphic images. It is yet another objective of the  
14   present invention to eliminate any mask or obstruction from the view of a viewer  
15   when reviewing stereo imagery.

16          It is yet another objective of the present invention to eliminate the parallax  
17   barrier from the view of viewers trying to visualize a three dimensional scene. In  
18   conventional parallax barrier type of lenticular lenses, very few aspects of a  
19   particular object are presented. Further, one screen, or plane, contains all of the  
20   information about the various aspects while the other screen (or mask) contains  
21   only the lenticular lens or running slit that isolates the left aspect from the right  
22   aspect of an image being viewed. Further, whenever a viewer uses a parallax  
23   barrier type of viewing system, the viewer is actually seeing the parallax barrier or  
24   the lenticular lens. This further limits the number of aspects of an image that can  
25   be seen by a viewer in attempting to view stereo graphic images.

26          The present invention is a system and method for three dimensional  
27   visualization based upon parallel information processing of stereo and multi  
28   aspect images. Further the processing is adaptive in nature so as to be  
29   continually processed as the location of the viewer changes. Thus the perception  
30   of 3 dimensional images by the viewer is improved by not constraining the viewer

1 in any meaningful way.

2 In the present invention, at least two LCD screens are positioned one  
3 behind an other. Each such screen is composed of multiple cells which  
4 collectively are capable of forming an image. The screens are transmissive, i.e.  
5 they both transmit light. An illumination means is positioned behind the screens  
6 to illuminate the LCD images created.

7 Each screen presents an aspect of the stereo image being viewed. The  
8 information is derived from the database of stereo pairs, or aspects, stored in a  
9 memory unit. A memory unit provides a stereo pair to the processing block which  
10 in turn controls the liquid crystal displays each of which displays an aspect of the  
11 image being viewed. Further the processing block controls the lighting unit which  
12 illuminates the liquid crystal displays.

13 Since each LCD contains all of the information about a particular aspect or  
14 view of the image in question, there is no loss of resolution such as that which  
15 occurs when both aspects must be displayed on a single screen or plane as with  
16 lenticular viewing systems.

17 The image, or corresponding pair of aspects, are presented to the viewer  
18 based upon a sensing of the viewer position. This viewer position signal is input  
19 to the processing block by means known in the art such as IR sensing of position  
20 or RF or ultrasonic tracking means which in turn retrieves a different stereo pair  
21 from the memory unit for subsequent presentation and display by the controller of  
22 the liquid crystal panels.

23 An image that is to be presented to a particular viewer is preliminarily  
24 processed and serves as a mask. Thus the viewer sees no images other than the  
25 object it self. This, in contrast to conventional parallax barrier type imaging  
26 systems where the mask can clearly be seen. In addition, this preliminary  
27 processing of the image results in the absence of noise and distortion of a visual  
28 nature such as that that this created by lenticular screens or lenses.

29 A Brief Description of the Drawings

30 Figure 1 illustrates the display system.

1           Figure 2 illustrates the computational and control architecture of the  
2 present invention.

3           Figure 3 illustrates the light beam movement of the present invention.

4           Figure 4 illustrates the data flow for the operation of the display control  
5 program.

6           As noted above, the present invention is a system and method for  
7 presentation of multiple aspects of an image to create a three dimensional  
8 viewing experience using two liquid crystal panels.

9           Referring to Figure 1, computational device 1 provides control for an  
10 illumination subsystem 2 and for the display of images on two discreet liquid  
11 crystal displays 4 and 6. Illumination source 2 which is controlled by the  
12 computational device 1 illuminates the transmissive liquid crystal displays 4 and 6  
13 which are displaying images provided to them by the computational device 1.

14           Referring to Figure 2, for the detail on computational device 1 is illustrated.  
15 The invention comprises a data base of stereo pairs or aspects 8 which are  
16 provided to the memory unit 12. Memory unit 12 has several functions. Initially  
17 memory unit 12 will extract and stage a particular stereo pair from the stereo pair  
18 data base 8. This stereo pair will correspond to an initial viewing position. As  
19 noted above a viewer position sensor 10 provides a viewer position signal to  
20 processing block 14.

21           All during the viewing session, the viewer position signal 10 is constantly  
22 monitored and provided to processing block 14. Depending upon the viewer  
23 position and subsequent error processing as noted (below) information from  
24 processing block 14 regarding viewer position 10 is provided to memory unit 12  
25 for subsequent extraction of the stereo pair aspects from the data base 8. Thus  
26 the present invention is constantly providing an updated series of stereo pairs  
27 based upon the viewer position 10.

28           Memory unit 12 provides the stereo pair to the liquid crystal control panel  
29 and lighting unit 16. LCD control and lighting unit 16 provides the left and right  
30 images to the appropriate LCD panels 4, 6 as well as controls the lighting that

1 illuminates the transmissive LCD panels 4, 6. Processing block 14 also provides  
2 instruction to LCD and lighting control unit 16 to provide the appropriate  
3 illumination as well as display of the stereo pairs.

4 It should be noted that memory unit 12 holds the accumulated signals of  
5 individual cells or elements of the liquid crystal display. Thus the memory unit 12  
6 has the ability to accumulate and analyze the light that is traveling through  
7 relevant screen elements of the LCD screens toward the right and left eyes of the  
8 viewer which are identified by the processing block 14 based upon the viewer  
9 position signal 10.

10 Referring to Figure 3 the diagram of the light beam movement of the  
11 present invention is illustrated. In this illustration a three panel liquid crystal  
12 display is illustrated. In this instance the display comprises an image presented  
13 on a near panel 18, a medium-distant panel 20 and a distant image panel 22. The  
14 relative position of these panels is known and input to the processing block for  
15 subsequent display of images.

16 Different portions of different aspects or each stereo pair are displayed in  
17 each element of panels 18, 20, and 22. In this illustration left eye 36 sees a  
18 portion 28 on panel 18 of an image. Since the panels are transmissive in nature,  
19 left eye 36 also sees a portion of one aspect of an image 26 on the medium  
20 distant LCD panel 20. Additionally, and again due to the transmissivity of each  
21 LCD panel, left eye 36 also sees a portion of one aspect 24 of an image which is  
22 displayed on a distant LCD panel 22. In this manner the portions of the image are  
23 those that are to be seen by the left eye of the viewer

24 Similarly, right eye 34 sees the same portion 28 of an aspect of an image  
25 on the near panel 18, as well as sees a portion of an aspect 30 of an image  
26 displayed on the medium distant panel 20 as well as a portion of an aspect 32 of  
27 an image on distant panel 22. These portions of the image are those that are to  
28 be seen by the right eye of the viewer.

29 These portions of aspects and mask seen by the right and left eye of the  
30 viewer constitute two views seen by the viewer thereby creating a stereo image.

1           Referring to Figure 4, the data flow for the manipulation of the images of  
2 the present invention is illustrated. As noted earlier the memory unit **12**  
3 processing block **14** and LCD control and luminous control **16** regulate the  
4 luminous radiation emanating from the far screen **22** and the transmissivity of the  
5 medium distant screens **20** and **18**.

6           Information concerning two discreet two dimensional images (two aspects)  
7 of an object each of which is depicted in multiple different areas on the LCD  
8 screens and information about positions of the right and left eyes of the viewer  
9 are adjusted by the processor block **14**.

10          Signals corresponding to the transmission of a portion **28** of near screen  
11 **18**, the transmissivity of medium-distant **20** corresponding to the left and right  
12 eye respectively (**26**, **30**) and the far screen **22** corresponding to the luminous  
13 radiation of those portions of the image of the left and right eye respectively (**24**,  
14 **32**) are input to the processing block following the set program.

15          The light signals from the cells of all screens which are directed toward the  
16 right and left eye of each viewer are then identified. In this example signals from  
17 cell **28**, **26**, and **24**, are all directed toward the left eye of the viewer **36** and  
18 signals from block **28**, **30**, and **32** are directed the right eye of the viewer **34**.

19          Each of these left and right eye signals are summed **38** to create a value  
20 for the right eye **42** and the left eye **40**. These signals are then compared in a  
21 compare operation **48** to the relevant parts of the image of each aspect and to the  
22 relevant areas of the image of the object aspects **44** and **46**.

23          Keeping in mind that the signal is important a function of the location of the  
24 viewer's eyes, the detected signal can vary to some extent. Any errors from the  
25 comparison are identified for each cell of each near mask, and distant screen.  
26 Each error is then compared to the set threshold signal and, if the error signal  
27 exceeds the set threshold signal, the processing block control changes the  
28 signals corresponding to the luminous radiation of at least part of the distant  
29 screen **22** cells as well changes the transmissivity of at least part of the medium-  
30 distant and near cells of the LCD displays.



1           If the information concerning discreet two dimensional images of two  
2 aspects of the object changes, as a result of movement of the viewer position, the  
3 processing block senses that movement and inputs into the memory unit signals  
4 corresponding to luminous radiation of the distant screen cells as well as the  
5 transmissiveness of the medium-distant and near screen cells until the  
6 information is modified. When the viewer position varies far enough to require a  
7 new view, that view or image is extracted from the database and staged to the  
8 LCD screens.

9           It should also be noted that the system of the present invention can be  
10 used with multiple viewers observing imagery simultaneously. The system simply  
11 recognizes the individual viewers' positions and stages images appropriate for the  
12 multiple viewers.

13           A system and method for the viewing of stereo imagery has now been  
14 shown. It will be apparent to those skilled in the art that other embodiments of the  
15 present invention are possible without departing from the scope of the invention  
16 as disclosed.

17

1

2 I claim:

3

- 4 1. A system for visualization of multi-aspect images comprising:  
5 a viewer position signal generator (VPSG);  
6 a processor connected to the VPSG and adapted to receive a viewer  
7 position signal indicative of the position of the viewer's eyes;  
8 a memory unit connected to the processor for receiving instructions from  
9 the processor for staging of stereopairs of images;  
10 a liquid crystal display (LCD) panel and lighting controller connected to the  
11 processor and to the memory unit for receiving the staged stereopairs of  
12 images and for receiving instructions from the processor; and  
13 at least two LCD display panels, each comprising cells, for displaying  
14 sections of the stereopairs of images on each panel, the LCD panels  
15 arranged one behind the other, and at least one of the LCD panels nearest  
16 the viewer being transmissive, and wherein each LCD panel displays part  
17 of each of the images of the stereopair of images.  
18
- 19 2. The system for visualization of multi aspect images of claim 1 wherein the  
20 at least two LCD panels further comprise a near, medium distant and  
21 distant LCD panel; and  
22 wherein the memory unit, processor and LCD and lighting controller  
23 regulate the luminous radiation of the distant LCD panel, and the  
24 transmissivity of the medium-distant and near LCD panels.  
25
- 26 3. The system for visualization of multi aspect images of claim 2 wherein  
27 signals corresponding to the luminous radiation of at least part of the  
28 distant LCD panel and the transmissivity of the medium-distant and near  
29 LCD panels are input to the memory unit by the processor; and  
30 wherein the processor further comprises instructions for identifying the

- 1 amount of light directed from the cells of the near, medium distant and  
2 distant LCD panels to the right and left eyes of a viewer; and  
3 wherein the processor further comprises instructions for comparing the  
4 amount of light detected from the cells of the near, medium distant , and  
5 distant LCD panels to a set threshold signal.  
6
- 7 4. The system for visualization of multi-aspect images of claim 3 wherein the  
8 processor further comprises instructions for calculating an error amount  
9 based upon the difference between the set threshold signal and the  
10 amount of light reaching the right and left eyes of the viewer; and  
11 the processor further comprising instructions for modifying the luminous  
12 radiation for at least part of the distant LCD panel, and the transmissivity of  
13 the medium-distant and neat LCD panels if the error amount exceed an  
14 error signal threshold.
- 15 5. A method for viewing multi-aspect imagery comprising:  
16 sensing and creating a signal for the position of at least one viewer's eyes;  
17 inputting the viewer position signal to a processor;  
18 staging steropairs of images to at least two LCD panels based upon the  
19 view position signal from a database of multi-aspect images; and  
20 displaying part of each steropair of images on the LCD panels  
21 corresponding to the right and left eyes of the viewer.  
22
- 23 6. The method of viewing multi-aspect imagery of claim 5 wherein the staging  
24 of stereopairs of images further comprises staging the stereopairs of  
25 images to a near, medium-distant and distant LCD panel; and  
26 regulating the luminous radiation of the distant panel, and the  
27 transmissivity of the medium-distant and near LCD panels.  
28
- 29 7. The method of viewing multi-aspect imagery of claim 6 further comprising:  
30 Inputting to a memory unit the signals corresponding to the luminous

- 1                    radiation of at least part of the distant LCD panel and the  
2                    transmissivity of a corresponding part of the medium-distant and  
3                    near LCD panels; and  
4                    comparing the amount of light to a set threshold .  
5  
6    8.    The method of viewing multi-aspect imagery of claim 7 further comprising:  
7                    calculating an error amount from the difference between the amount of  
8                    light and the set threshold; and  
9                    modifying the luminous radiation for at least part of the distant LCD panel if  
10                    the error amount exceeds and error threshold.  
11  
12

**AMENDED CLAIMS**

[received by the International Bureau on 12 March 2001 (12.03.01);  
original claims 1,5 and 6 amended;  
remaining claims unchanged (2 pages)]

- 1  
2  
3  
4 1. A system for visualization of multi-aspect images comprising:  
5 a viewer position signal generator (VPSG);  
6 a processor connected to the VPSG and adapted to receive a viewer  
7 position signal indicative of the position of the viewer's eyes;  
8 a memory unit connected to the processor for receiving instructions from  
9 the processor for staging of stereopairs of images;  
10 a liquid crystal display (LCD) panel and lighting controller connected to the  
11 processor and to the memory unit for receiving the staged stereopairs of  
12 images and for receiving instructions from the processor; and  
13 at least two LCD display panels, each comprising cells, for displaying  
14 sections of the stereopairs of images on each panel, the LCD panels  
15 arranged one behind the other, and at least one of the LCD panels nearest  
16 the viewer being transmissive, and wherein each LCD panel displays part  
17 of each of the images of the stereopair of images without any polarizing  
18 elements separate from said LCD display panels.  
19
- 20 2. The system for visualization of multi aspect images of claim 1 wherein the  
21 at least two LCD panels further comprise a near, medium distant and  
22 distant LCD panel; and  
23 wherein the memory unit, processor and LCD and lighting controller  
24 regulate the luminous radiation of the distant LCD panel, and the  
25 transmissivity of the medium-distant and near LCD panels.  
26
- 27 3. The system for visualization of multi aspect images of claim 2 wherein  
28 signals corresponding to the luminous radiation of at least part of the  
29 distant LCD panel and the transmissivity of the medium-distant and near  
30 LCD panels are input to the memory unit by the processor; and

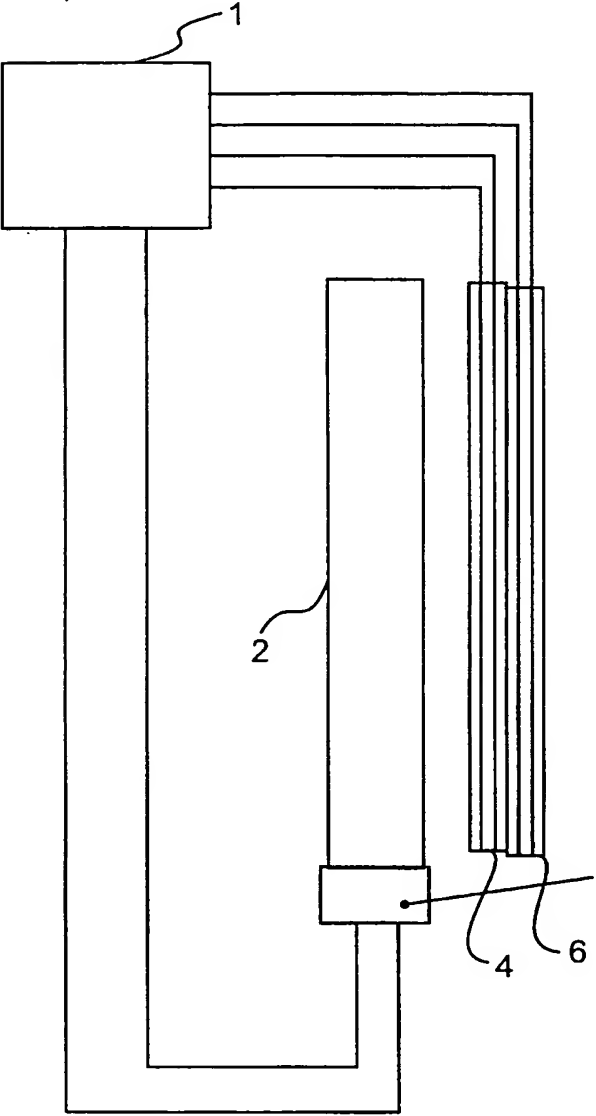
- 1 wherein the processor further comprises instructions for identifying the  
2 amount of light directed from the cells of the near, medium distant and  
3 distant LCD panels to the right and left eyes of a viewer; and  
4 wherein the processor further comprises instructions for comparing the  
5 amount of light detected from the cells of the near, medium distant , and  
6 distant LCD panels to a set threshold signal.  
7
- 8 4. The system for visualization of multi-aspect images of claim 3 wherein the  
9 processor further comprises instructions for calculating an error amount  
10 based upon the difference between the set threshold signal and the amount  
11 of light reaching the right and left eyes of the viewer; and  
12 the processor further comprising instructions for modifying the luminous  
13 radiation for at least part of the distant LCD panel, and the transmissivity of  
14 the medium-distant and neat LCD panels if the error amount exceed an  
15 error signal threshold.  
16
- 17 5. A method for viewing multi-aspect imagery comprising:  
18 sensing and creating a signal for the position of at least one viewer's eyes;  
19 inputting the viewer position signal to a processor;  
20 staging stereopairs of images to at least two LCD panels based upon the  
21 view position signal from a database of multi-aspect images; and  
22 displaying part of each stereopair of images on the LCD panels  
23 corresponding to the right and left eyes of the viewer without using any  
24 polarizing elements separate from said LCD display panels.  
25
- 26 6. The method of viewing multi-aspect imagery of claim 5 wherein the staging  
27 of stereopairs of images further comprises staging the stereopairs of  
28 images to a near, medium-distant and distant LCD panel; and  
29 regulating the luminous radiation of the distant panel, and the transmissivity  
30 of the medium-distant and near LCD panels.  
31

Statement under Article 19(1)

By the present amendment, claim 1 has been amended to correct the spelling of "receiving" and define the system as "without any polarizing elements separate from said LCD display panels;" claim 5 has been amended to define the method "without using any polarizing elements separate from said LCD display panels;" and claim 6 has been amended to correct the spelling of "luminous." All the remaining claims are unchanged.

The display of U.S. 5,973,831 uses polarizing elements separate from any LCD display panels.

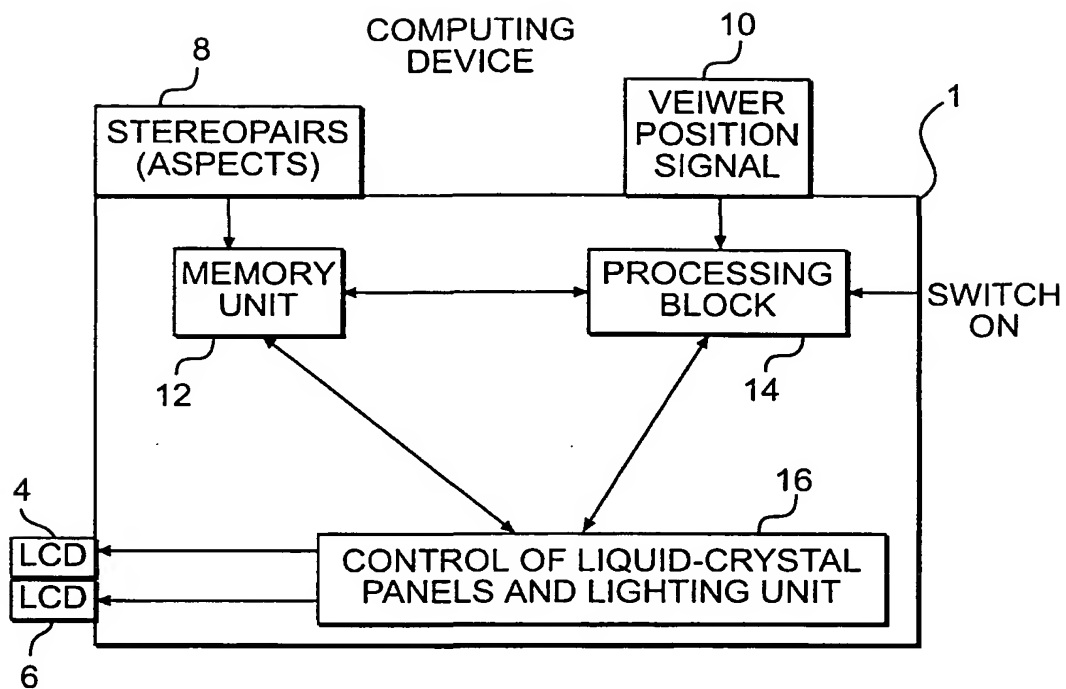
1/4  
NEUROSTEREODISPLAY SYSTEM



**FIG. 1**



2/4

**FIG. 2**

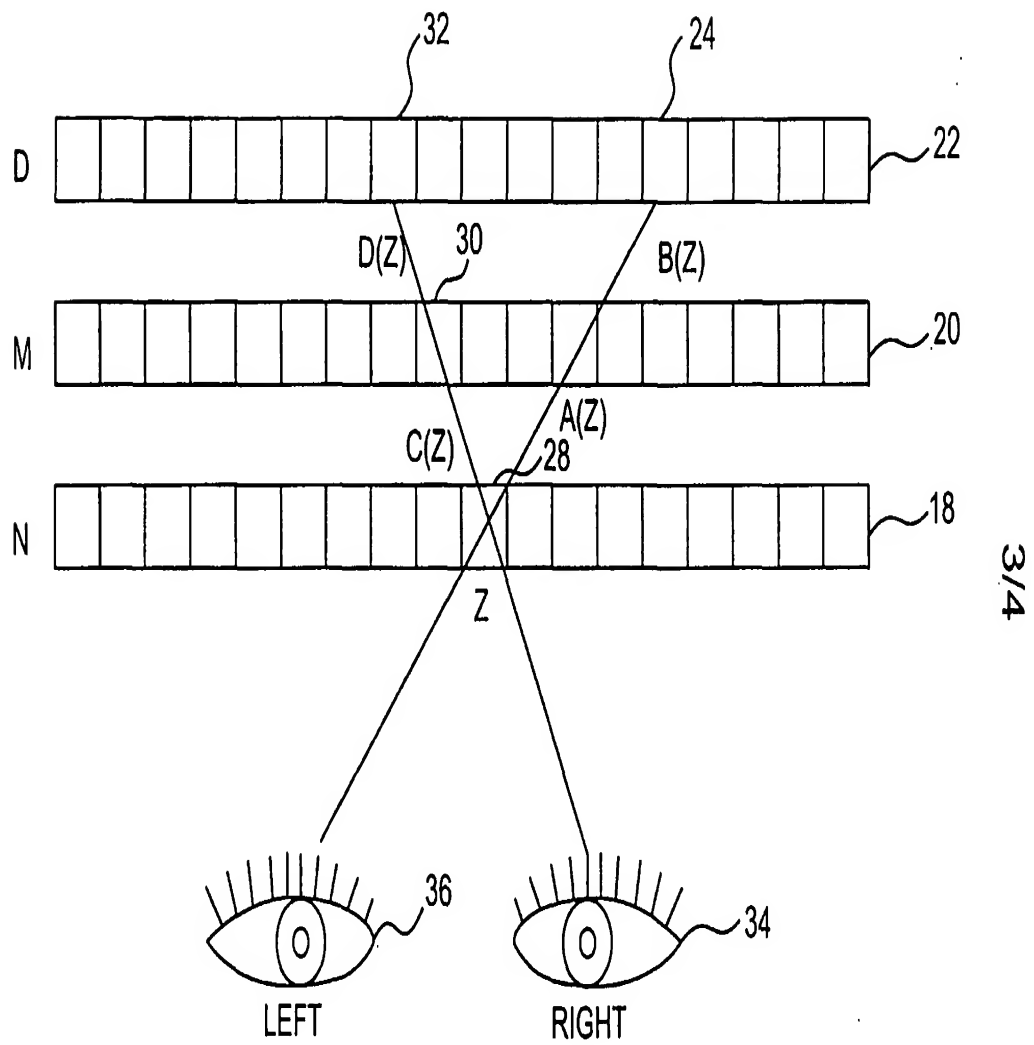
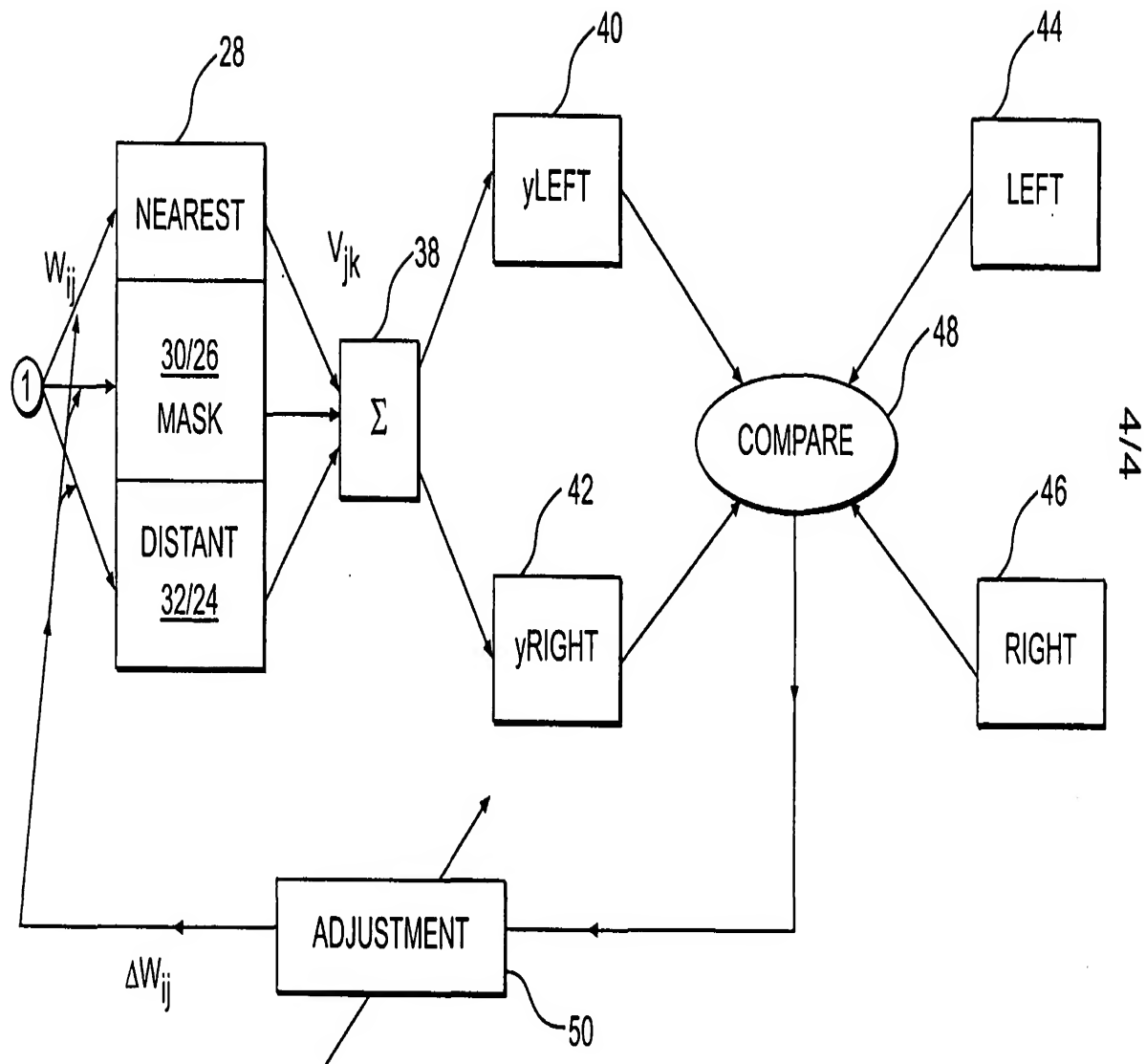


FIG. 3

**FIG. 4**

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 00/30683

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 H04N13/04 H04N13/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages   | Relevant to claim No. |
|------------|--|-----------------------|
| X          | US 5 973 831 A (KLEINBERGER ILAN D ET AL)<br>26 October 1999 (1999-10-26)<br>column 32, line 30 -column 34, line 30;<br>figures 18-21<br>----- | 1-3,5,6               |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

5 January 2001

Date of mailing of the international search report

12/01/2001

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

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